Nondestructive Evaluation (NDE)
Annual Technical Plan
323-78

S&MA Annual Technical Plan

Level 2A

Approval: Ed Generazio

NDE Program Manager

Concurrance: _____

Code QT Division Director

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Task Title: Correlation of Neutron Computed Tomography with X-Ray Computed Tomography for Unique Nondestructive Examinations

I. Objectives: Develop techniques by which to scale Neutron Computed Tomography (NCT) image files and X-Ray Computed Tomography (XCT) image files for direct digital comparisons, unique analysis, and simultaneous display on computer systems.

II. Center Point of Contact:

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III. Technical Methodology/ Approach:

Background: The advantages of computed tomography (CT) have been demonstrated in many facets of NonDestructive Examination (NDE) applications. The CT method has been successfully applied to many NDE technologies such as neutron radiation, X-ray radiation, gamma radiation, nuclear-magnetic radiation, and ultrasonic radiation. The underlying radiographic technologies also have been greatly enhanced using the CT approach. A few examples are gamma CAT scans, PET scans, and MRI scans in medicine, corresponding to XCT and NCT in industrial applications.

Each technology applied to NDE has been shown to have unique advantages for detecting specific anomalies in tested subjects. For example XCT and gamma CT are superb for detecting minute material density gradients, whereas NCT and MRI excel for detecting nuclear isotopic differences. NDE practioners readily acknowledge that the different technologies are clearly complementary. Nevertheless, each technology was typically developed independently with specific applications in mind, and development of each technology tended to be rather distinct from every other.

During diagnostic investigations of aerospace components at the NASA White Sands Test Facility (WSTF), different technologies have been recognized to provide optimum images of specific substructures of each component. For example, minute damage to valve sealing softgoods was found to be readily detectable using NCT, whereas intricate damage to metallic substructures was more evident using XCT. Yet few organizations have the capabilities or resources to apply all of the appropriate technologies in house, not to mention the economic trend of out-sourcing much more work.

NDE specialists at WSTF have, nevertheless, experienced the frustration of how to quantitatively confirm the qualitative visual observations made from image comparisons generated by diverse technologies. The proposed investigation is a step toward quantitatively correlating the images from the application of independent examinations performed with selected technologies.

Methodology: The approach involves the determination of methods for relative scaling of digitized images with sufficient accuracy to permit direct machine comparisons or perform composite visual displays to support accurate interpretation of observed anomalies. The current investigation proposes the limitation of this initial development only to two of the technologies important to WSTF, namely, NCT and XCT. However, the extension of the method to other technologies seems conceptually feasible, albeit not necessarily straightforward.

The first step in the proposed investigation will be the development, qualification, and calibration of a suitable dimensional phantom. The phantom must deliver precise dimensional integrity appropriately both for N-rays and X-rays, and it should be relatively simple, sufficiently robust, relatively small, and easily incorporated into both NCT and XCT systems.

The next step will be to demonstrate the accuracy of the dual phantom compared to existing industry-recognized standards, such as an N-ray image quality indicator (IQI) and an equivalent X-ray IQI. The demonstration will be established for film images as well as digital images in order to confirm the link between these technologies. Appropriate images will be accumulated to document the accuracy demonstration.

Finally, computer software will be developed to digitally scale the relative image data of image files generated by the two different processes and detection apparatus. Edge enhancement and edge definition algorithms will be incorporated to adjust image dimensions to the pixel level. Investigations will be performed to determine the effects of various image-enhancement algorithms on measured dimensions. The plan is to incorporate this software with the Laurence Livermore National Laboratories (LLNL) port of CT image reconstruction software on the WSTF XCT system implementation, and to coordinate the development with that being performed by the NDE group at the DOE Savannah River Site.

IV. Customers:

Dr. Steve Schneider, LaRC, 216-977-7484 - Distribution of Mars Observer Corrective Action Test Program (MOCATP) actions to NASA programs and industry
David Price, MSFC, 205-544-7085, Space Station - Interim Control Module (ICM)
Robert Moreland, JSC, 281-483-7547 - Space Station ICM
Claude Smith, NASA HQ, 202-358-1675 - Spacecraft pyrotechnic safety

V. Metrics:

The project schedule/milestones as well as project data will be reviewed with the customers on a weekly basis. Project success will be indicated by the development of practical methods to scale NCT and XCT image files for direct digital overlay display on a computer visualization system.

VI. Products:

FY02 – Computer software to accomplish image file scaling based on correlation of image data. Preliminary demonstration of the measurements and processing on typical files by the end of the second year.

VII. Schedules/Milestones:

FY02

1st Qtr

- Start Test Plan and Delivery Order Development (Funding typically not available at WSTF until Dec.)

2 nd Qtr

- Perform literature search for N-ray and X-ray IQI and resolution standards
- Design dimensioning phantom and submit proposed to one of more reviewers
- Fabricate dimensioning phantom to design specifications

3 rd Qtr

- Submit phantom for film radiography, digital radiography, and CT to generate actual files for processing
- Perform data analysis to confirm accuracy limits for phantom resolution
- Coordinate task activity with developments at NDE group at Savannah River

4th Qtr

- Establish a software development subplan including compilation of appropriate sources and potential public domain offerings
- Integrate LLNL software and SRS enhancements with WSTF system
- Submit interim report

FY03

1st Qtr

- Start development of software modules to implement selected algorithms (Funding typically not available at WSTF until Dec.)

2 nd Qtr

- Integrate modules with WSTF-platform software
- Test integrated software with typical image files generated heretofore
- Debug code to fulfill the functionality desired for the algorithm and the assocated process

3 rd Qtr

- Incorporate other software-manipulation modules into the platform software as available
- Test the functionality and compatiblity of the modified platform software for processing of typical image files
- Investigate the potential impact of the application of system software on the accuracy and scaling of manipulated image files
- Coordinate task activity with developments at NDE group at Savannah River

4th Qtr

- Completely document the use and functions of the generated software
- Coordinate software development with McClellan Nuclear Radiation Center upgrade plans
- Submit final report